



THE RELATION OF ALUMINIC AND FERRIC SALTS TO PLANT LIFE.

BY PROF. PETER T. AUSTEN, PH.D., F.C.S.

The action of minute amounts of substances in aiding plant life has been known for a considerable time. Liebig drew frequent attention to the effect of small amounts of chlorides, etc., in decomposing phosphates, and others have stated that the mineral salts in solution helped the filtration of water by the soil. Attention has been directed, however, chiefly to the removal of suspended matters, rather than the precipitation of organic substances.

The study of the relation of plant life to its foods and wastes is, indeed, interesting, and brings out vividly the adaptations here involved. The animal is an analytic being, and has to have its food prepared for it. It cannot live on the elements, but must have its nutriment worked up into starch, protein, and other highly constituted compounds. In the midst of infinite amounts of carbon, oxygen, nitrogen, and all the elements of its food, the animal would still starve, unless the plant were present to collect, by means of its synthetic processes, these various substances, and prepare from them the food necessary to animal life. The animal eats the products of the plant, fruits, seeds, leaves, or it may be other animals, and by its analytic processes breaks them up into simple substances, which pass again into the ceaseless circulation of matter, to be again synthesized by plants and again analysed by animals.

But the animal has the power of locomotion, and it goes where it will, seeking its food where it finds it the best, or the most easily, and settling in the environment most suitable to it. The plant, however, is stationary.¹ It cannot move about and

1. These are broad definitions. I am aware that some of the lower forms of plant life have the power of motion, and that certain species of animals have not the power to move out of their environments.

seek its nutriment, hence nature brings food to it. The rain falls on the mountains and washes them down, undermines them, planes them with glaciers, grinds them with rocks, cracks them with ice, pulverizes the pieces by attrition, and bears the fine mineral matters down to the fertile plains. The water runs to the ocean, evaporates and falls again as rain, thus keeping up the continual cycle. Against the mountains, water acts like a huge grindstone, which nature keeps continually in motion. The rain, falling through the air, dissolves carbonic acid, and the water thus acidified dissolves vast amounts of lime,¹ and other valuable plant foods, and carries them to the plant. Strangely, too, the plant, when it dies and rots, gives off carbonic and other organic acids, and these dissolving in the water rob the rocks of fresh supplies of mineral food, which the ever-circulating and percolating currents of water bring to the plants' progeny, so that it may be said, plants die that others may live.

This continual flow of water on and in the earth bears the same relation to the earth that the blood does to an animal. It carries the nutriment in solution, and bears away the effete matters and products of life. It seems to be a law, not yet well recognized, that every organized being, plant or animal, will die unless the products of its life are well removed. In other words, both plants and animals are continually producing the means of their own death, and are more or less dependant (the former almost entirely) on natural laws for the removal of the danger. The result of life is death.

The soil also has its part to carry out. As the water containing the food of the plant percolates through it, the phosphates are seized on and bound securely within a few inches of the surface, so vigilant are the oxides of iron and aluminum to the wants of the plant. But little further does the potash go, when it is imprisoned and held for future use. Only small amounts of these substances fall in the rain, and hence must come by moving water, so the soil holds them tightly. In the rain come down continually nitrogen compounds, but the soil affords little obstruction to them, for more will come, and their accumulation might do harm in forcing leaf growth. To the

1. The Rhine carries into the ocean yearly lime enough to satisfy 332½ millions of oysters.

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mineral substances which the plant does not require, the soil gives a free pass, and they go their way unmolested.

In this relation the peculiar power of aluminic and ferric salts to aid the clarification of water seems to come into play. A short time since I examined, with Prof. F. A. Wilber, the effect of alum in purifying water,¹ the clarifying power of which has been known for many years. Jeunet² states that the addition of 0.4 grms. to a litre of water will cause the impurities to settle in from seven to seventeen minutes. We found, however, that a much smaller amount of alum would cause precipitation and clarification. The New Brunswick city water contains in the winter considerable clayey matters, which are very fine, and cannot be removed either by settling or filtering through paper. The suspended matter in water is frequently in an astonishingly fine state of division. The water of the river Rhine, at Bonn, for example, does not settle in four months, and cannot be cleared by filtration.

The addition of 0.4 grms of alum did not cause the precipitation of the suspended matters in seventeen minutes, as stated by Jeunet, but after ten to twelve hours a considerable amount of a voluminous precipitate was formed, and the supernatant liquid became perfectly clear. Following the matter up, it was found that this coagulation took place when only 0.02 grams of alum were added to a litre of water (1.6 grains to the gallon). Still, smaller amounts of alum caused the precipitation, but a greater time was required. 0.02 of a gram of alum seemed, however, to be about the limit of action of the alum to produce a clear filtration of this particular water. Water treated with this amount can be at once filtered, and will run through clear and brilliant. Smaller amounts will effect a clarification by filtration, but the water must be allowed to stand some time before filtering. In the filtered water (treated with 0.02 gram alum) no further precipitation was produced by the addition of more alum, and no appreciable traces of alumina could be detected in the water thus purified. The alum acts, without doubt, as suggested by Jeunet, by the formation of a basic aluminic sulphate which

1. The full investigation will be found in the Report of the State Geological Survey of New Jersey for 1884.

2. *Moniteur Scientifique*, 1865, 1007.

envelopes the suspended matters and coagulates the organic substances, carrying them down together. The sulphuric acid, set free in the formation of the basic aluminic sulphate, attacks the calcium carbonate, etc., which are always present, forming sulphates, and setting carbonic acid free. Ferric salts appear to be about as active as alum, but we have not yet determined the limit of their action with exactness.

A number of salts were tested to determine this effect in causing the clarification of water by filtration, but as yet none have been found to equal in efficiency aluminic and ferric salts. To determine the nature of the precipitated matter, fifty liters of New Brunswick hydrant water were precipitated by adding two grams of alum. The whole was allowed to stand two days, then carefully siphoned off, and the slimy precipitate brought on a filter, dried and analysed. It gives:—

Carbon.....	16.53 per cent.
Hydrogen.....	2.02 "
Nitrogen.....	0.76 "
Ash.....	59.28 "

The ash contained silica, phosphoric acid, alumina, and oxide of iron, the latter in considerable amount.

The minute amount of alum that produces the precipitation is remarkable. 0.02 grams to a liter is 0.002%. As it is the aluminic sulphate beyond all doubt which acts as the precipitant, and as alum contains 36.1% of aluminic sulphate, the amount of the latter causing the clarification of a liter of water is 0.0072 grams; or referred to the weight of the water 0.00072%; in grains per gallon, 0.57. This result, like many others which have been obtained in late years, shows what important parts may be played by minute traces of elements. We may yet find that the wide distribution of titanium,¹ zirconium,² yttrium³ and copper,⁴ have a far deeper meaning than we can at present ascribe to them.

In all waters which percolate through the soil, there are found small amounts of iron and aluminium oxides. It is fair to infer that

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1. In soil, and in the ashes of coal plants.
 2. In clay.
 3. In lime.—*Crookes' Chem. News*, 49, 159, et seq.
 4. In wheat and the human liver.

See page 5, on the back of pg. 2.

the organic acids which are formed by the decomposition of plants act slightly on the ferric and aluminic compounds¹ in the soil, and thus impregnate the water with small amounts of soluble salts of these metals. The action of these substances would be to cause a precipitation of the organic matter held in solution, and the coagulation of the suspended inorganic matters, and to effect their removal on percolation through the soil. The substances thus precipitated are of high value as plant food. The nitrogen is in a most available state, and the phosphoric acid is also in an easily assimilable condition. The large amount of carbonaceous matter will afford the best nutriment to the many fermentations which take place in the soil, and thus establish suitable *nidi* for the bacterial life so necessary to the opening up of the land.

Thus we see that when the soil is unable directly to bind the plant nutriment, the acid products of the death of the plant, and probably also of the bacterial fermentations, supply agents which precipitate these plant foods in such a state that mere mechanical filtration will remove them, and leave them stored up for future use by the plant. Here again plant life serves the animal, for rain falling on the fields and washing into the earth in an impure state percolates through the soil, is coagulated and filtered to appear again as sparkling spring water, pure and wholesome, Nature's Nectar.²

Chemical Laboratory of Rutgers College.

1. The oxides of iron and aluminium, which are dissolved by the carbonic acid in water, would doubtless be decomposed by the action of organic acids to form aluminic and ferric salts.

2. The remarkable action of alum in aiding the filtration is well shown in the large Hyatt filters, now in use in many manufacturing establishments.

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99 LIVINGSTON STREET.

In answer to yours of

Prof. H. W. Wiley,

U. S. Dept. of Agriculture,

Washington, D. C.

My dear Dr. Wiley:-

The paper entitled "The Relation of Aluminic and Ferric Salts to Plant Life" was published in the School of Mines Quarterly. I forget the date but will look it up and will let you know. Since I drew attention to the fact that coagula-filtration takes place in nature several have published articles on the same subject, evidently without having seen my article. I have taken a great deal of pleasure in sending these gentlemen copies of this article with a courteous letter, expressing my gratification at their confirmation of my views. I brought up the same subject in an article on water filtration, a copy of which I enclose.

Yours very truly,

Peter T. Austen

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MEMORANDA.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ANIMAL INDUSTRY.

Washington, D. C.,

Dr. Wiley —

Can you tell
where & when this
effusion first came
light, also correct paginal
Stiles

Dr. Stiles.

We wrote a note to Dr. Austen to which he sent us the accompanying reply. Any further information sent by him I will refer to you.

M.S. Field.

